

Modular Energy Storage Benefit and Cost for Three Emerging Value Propositions

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Introduction

- Goal: high level evaluation of modular ESS benefit and cost using *consistent bases*
- Objectives
 1. update ESS cost data
 2. establish framework for “generic” financials
 3. concrete examples of B/C estimates for three emerging ESS value propositions
- Joint effort
 - Longitude 122 West -- ESS costs
 - Distributed Utility Associates -- ESS benefits

History

- ☞ Update DOE's existing ESS *costs*
- ☞ Evolution of DOE's ESS *benefits* work
 - Start Date: April, 2005 (Life-cycle cost framework was developed in prior years.)
 - Major Accomplishments prior to FY06
 - preliminary benefit / cost analysis, presented at EESAT 2005.
 - Summary of FY06 Milestones:
 - completion of the analysis
 - completion of the report

Three Value Propositions

1. Utility-owned *transportable* storage
 - typical T&D upgrade deferral (alternating years)
 - localized PQ or reliability (alternating years)
2. Utility-owned *stationary* storage
 - single year, high value T&D upgrade deferral
 - nine years electricity price arbitrage
3. Electricity End-user-owned storage
 - avoid critical peak charges
 - avoid on-peak energy and demand charges
 - *could* improve on-site PQ and/or reliability (not included)

Economic Assumptions

Common Bases

Time Horizon*: 10 years

Price Escalation (inflation): 2.5%

Discount Rate: 10%

Utility Fixed Charge Rate**: 0.11

End-user Annualization Factor**: 0.15

Comments? Please provide them to John Boyes

* ESS salvage or remaining value, if any, is not included in *this* evaluation; though it could be accommodated by subtracting the present value from lifecycle cost.

** Used to estimate annual “level” carrying charges for capital plant. 0.11 represents a fixed charge rate for typical utilities whereas 0.15 reflects higher opportunity cost associated with capital projects for commercial end-users.

Storage Technologies

<u>Value Proposition 1</u> Transportable; T&D Deferral + PQ/Temp.	<u>Value Proposition 2</u> High Value T&D Deferral + Arbitrage	<u>Value Proposition 3</u> Critical Peak Pricing + PQ/Rel.
Lead-acid batteries, conventional and VRLA Na/S batteries Ni/Cd Li-ion batteries Zn/Br batteries V-redox batteries High-speed and low- speed flywheels Lead-carbon asymmetric caps Hydrogen fuel cell	Lead-acid batteries, conventional and VRLA Na/S batteries Ni/Cd Li-ion batteries Zn/Br batteries V-redox batteries Surface CAES Lead-carbon asymmetric caps Hydrogen fuel cell	Lead-acid batteries, conventional and VRLA Na/S batteries Ni/Cd Li-ion batteries Zn/Br batteries V-redox batteries Surface CAES Lead-carbon asymmetric caps Hydrogen fuel cell

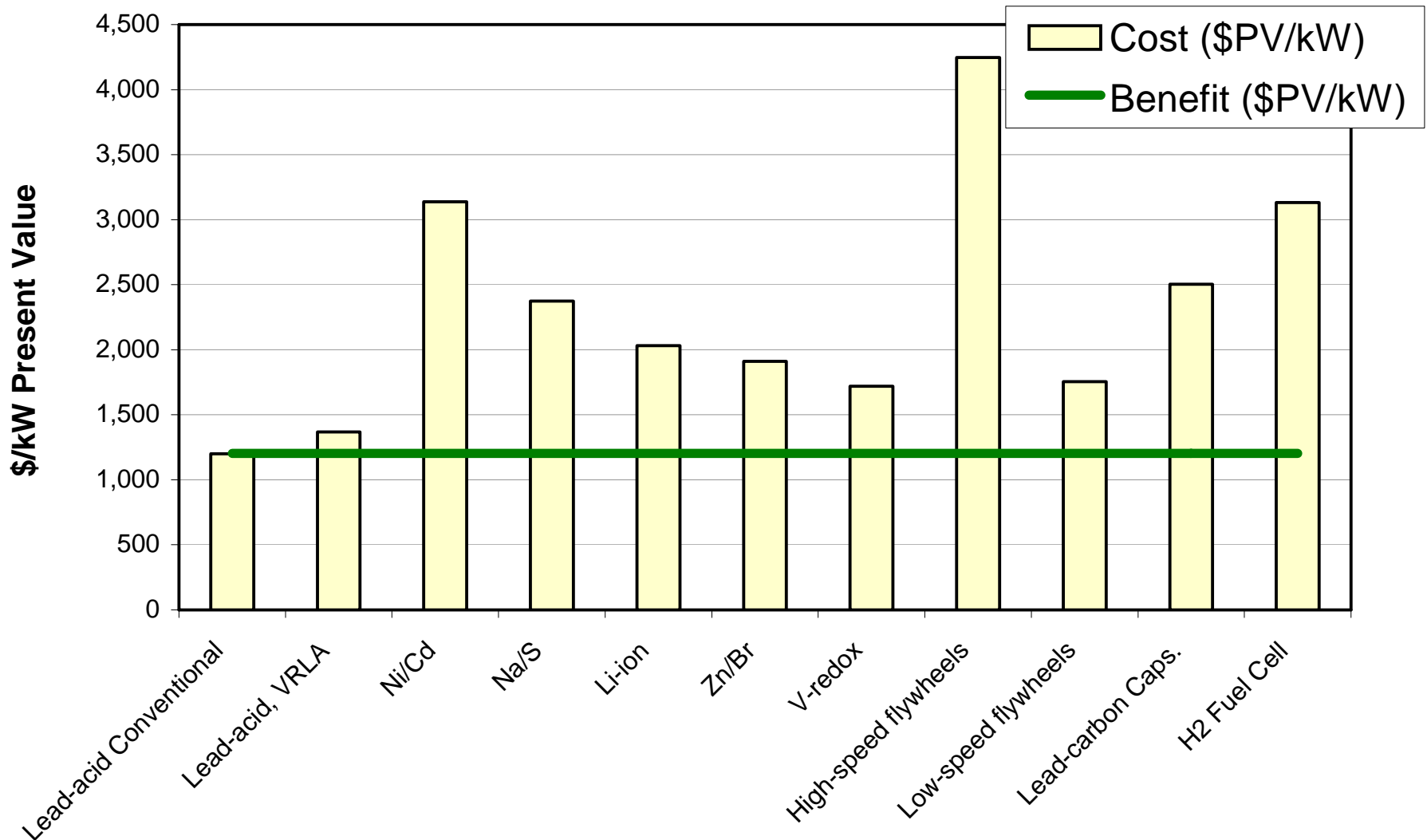
Operation for Value Proposition 1

Transportable ESS for T&D Deferral & PQ



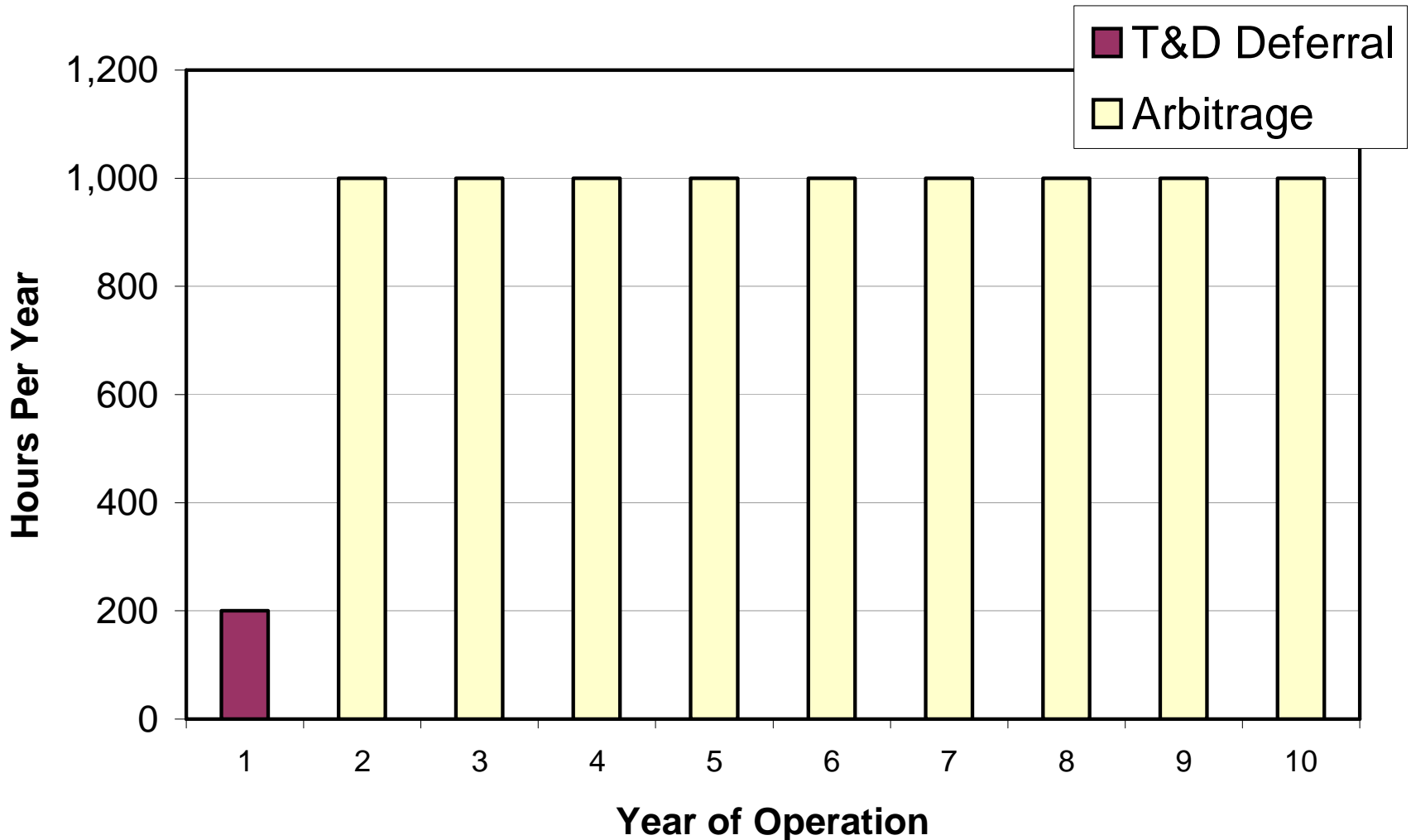
Benefit & Cost, Value Proposition 1

Transportable ESS for T&D Deferral & PQ



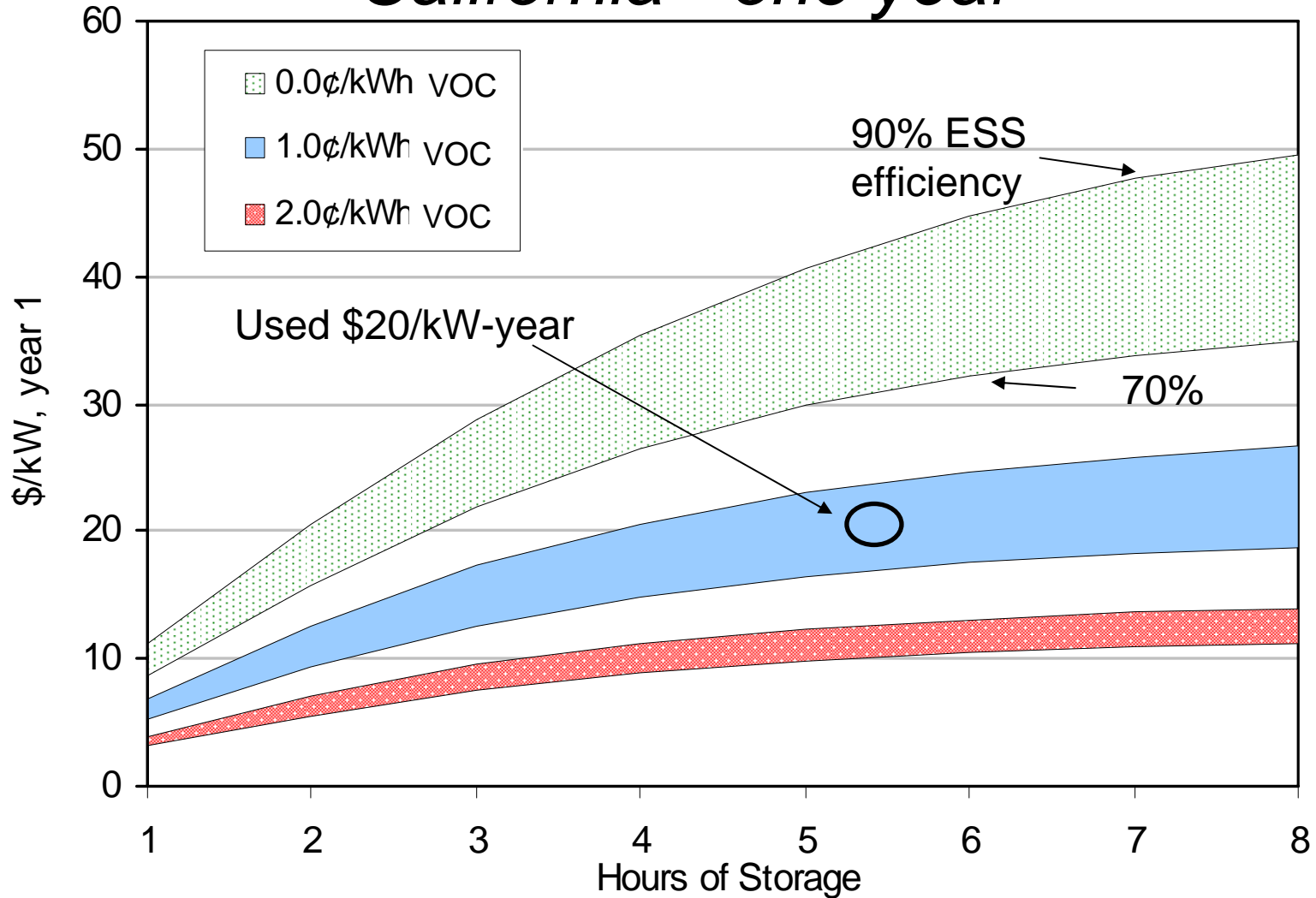
Operation for Value Proposition 2

1 Year High Value T&D Deferral + Arbitrage



Net* Arbitrage Benefits

California - one year

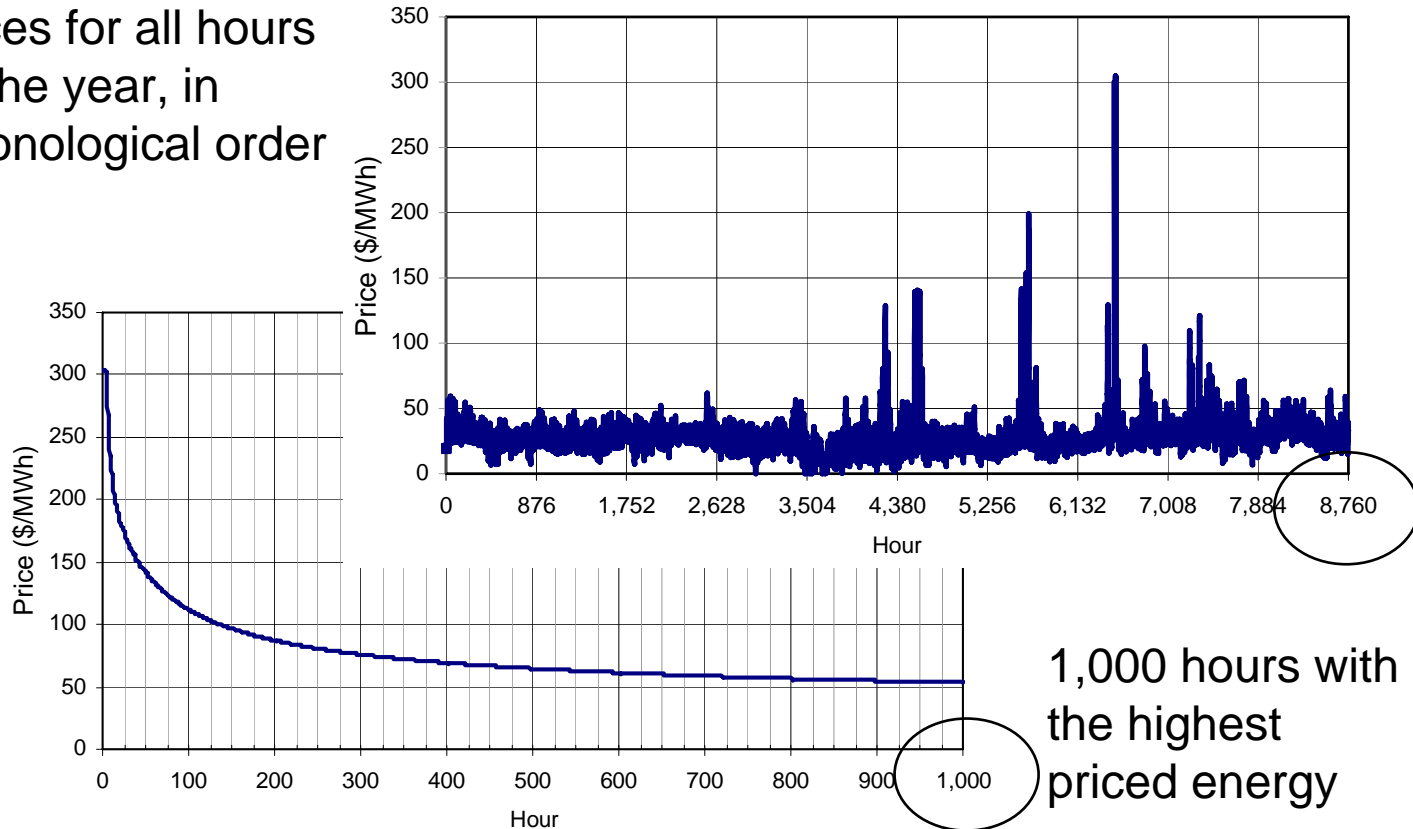


*Revenue - Charging Cost (with losses) - Variable Operating Cost (with replacement cost)

California Electric Energy Prices

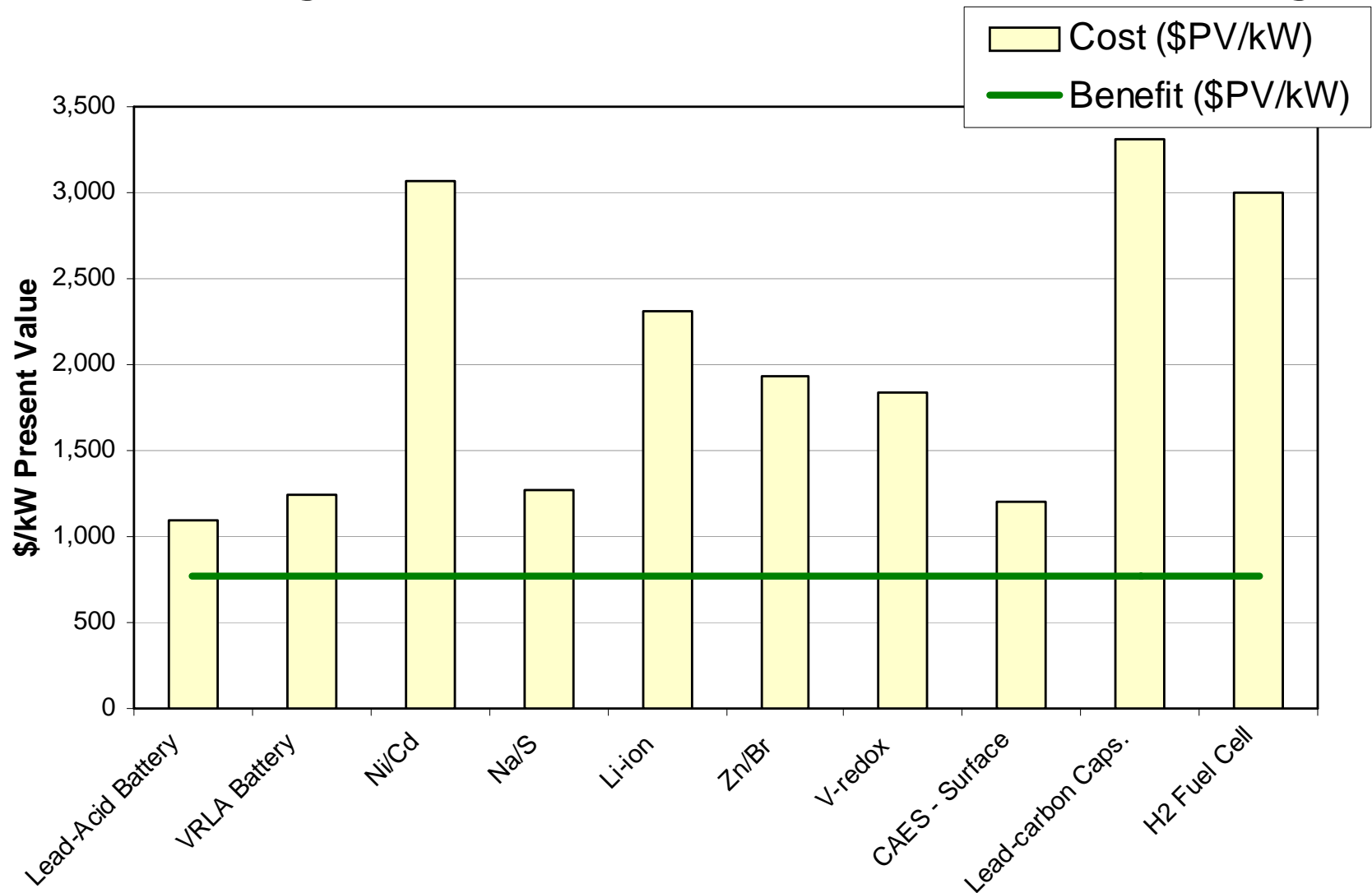
- 8,760 hourly wholesale prices
 - from CEC, production simulation model results

Prices for all hours
in the year, in
chronological order



Benefit & Cost, Value Proposition 2

1 Year High Value T&D Deferral + Arbitrage



Critical Peak Pricing



Pacific Gas and Electric Company
San Francisco, California

Cancelling

Revised
Original

Cal. P.U.C. Sheet No.
Cal. P.U.C. Sheet No.

23450-E
21686,
22861-E

SCHEDULE E-CPP—CRITICAL PEAK PRICING PROGRAM

APPLICABILITY: The critical peak pricing (CPP) program is a voluntary alternative to traditional time-of-use rates. Schedule E-CPP is available to PG&E bundled-service customers with billed maximum demands of 200 kW or greater during any one of the past 12 billing months, and served on PG&E Demand Time-Of-Use (TOU) electric rate schedules A-10 TOU, E-19 (including E-19 voluntary), E-20, AG-4 (rates C and F only), AG-5 (rates C and F only) or their successors. Each customer must continue to take service under the provisions of their otherwise-applicable schedule (OAS). The CPP program only operates during the summer months (May 1 through October 31). Customers on this tariff must agree to allow the California Energy Commission (CEC) or its contracting agent to conduct a site visit for measurement and evaluation, and agree to complete any surveys needed to enhance the CPP program. This program will remain in place until superseded by a mandatory CPP rate schedule, which is expected in the Advanced Metering OIR, Rulemaking (R.) 02-06-001 or subsequent filings. (T)

	Non-CPP Days (Credit) per kilowatt hour of usage		CPP Days (Charge) per kilowatt hour of usage	
	On-Peak	Part-Peak	Moderate-Price	High-Price
E-20T	\$0.02682 (R)	\$0.00146 (R)	\$0.09116 (R)	\$0.45124 (R)
E-20P	\$0.03012 (R)	\$0.00153 (R)	\$0.10010 (R)	\$0.48280 (R)
E-20S	\$0.03424 (R)	\$0.00349 (R)	\$0.10415 (R)	\$0.58900 (R)
E-19T	\$0.03102 (R)	\$0.00259 (R)	\$0.14360 (R)	\$0.54340 (R)
E-19P	\$0.03104 (R)	\$0.00230 (R)	\$0.11879 (R)	\$0.49672 (R)
E-19S	\$0.03656 (R)	\$0.00394 (R)	\$0.12429 (R)	\$0.59652 (R)
A-10T	\$0.01392 (R)	\$0.00627 (R)	\$0.11735 (R)	\$0.22991 (R)
A-10P	\$0.04076 (R)	\$0.00318 (R)	\$0.21143 (R)	\$0.67480 (R)
A-10S	\$0.04686 (R)	\$0.00322 (R)	\$0.22008 (R)	\$0.65292 (R)
AG-4C, F	\$0.02305 (R)	\$0.00583 (R)	\$0.12857 (R)	\$0.41080 (R)
AG-5C, F	\$0.01874 (R)	\$0.00504 (R)	\$0.09670 (R)	\$0.34808 (R)

Value Proposition 3

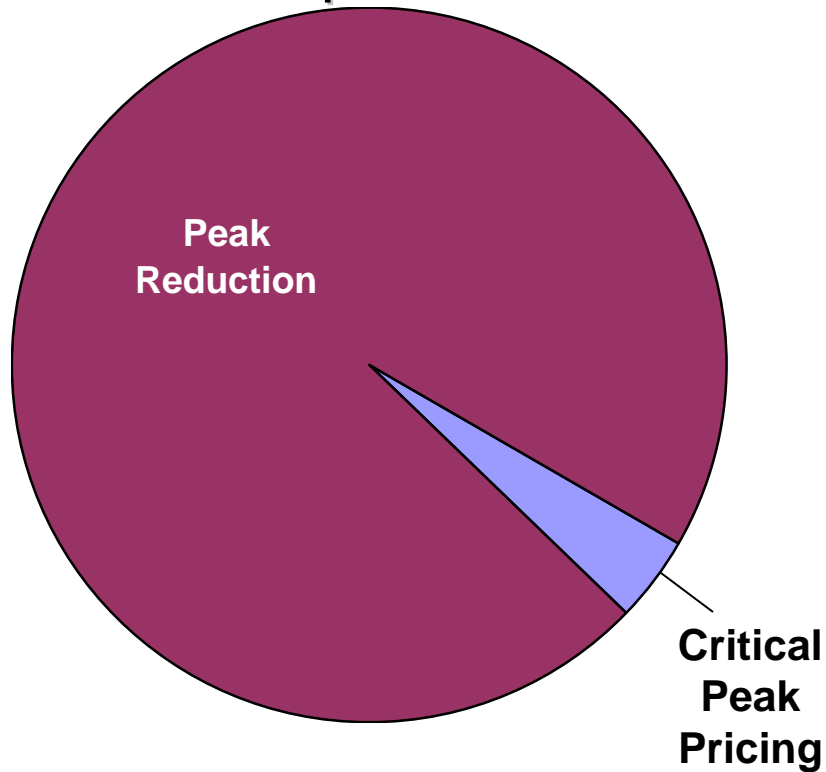
Critical Peak Pricing + Peak Reduction

- PG&E Critical Peak Pricing:
For discount during most hours of the year, customer agrees
 - to pay “very high” price for energy
 - up to 5x normal peak energy charge
 - “several times” (events) per year
 - PG&E Target: 12
 - for a target of 3 to 6 hours per event
- Note: some end-users could benefit from better onsite PQ and/or reliability.

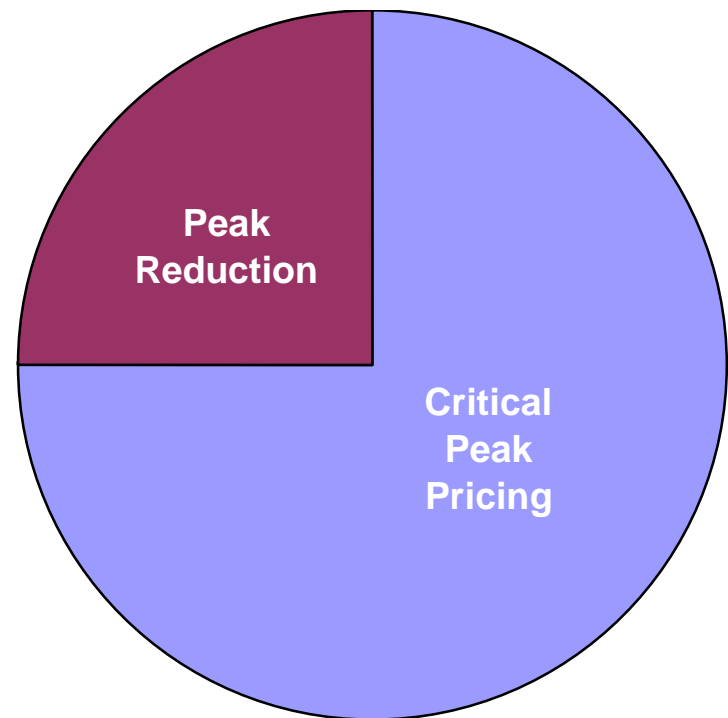
Value Proposition 3

Critical Peak Pricing + Peak Reduction

1,600 Annual Hours
of Operation

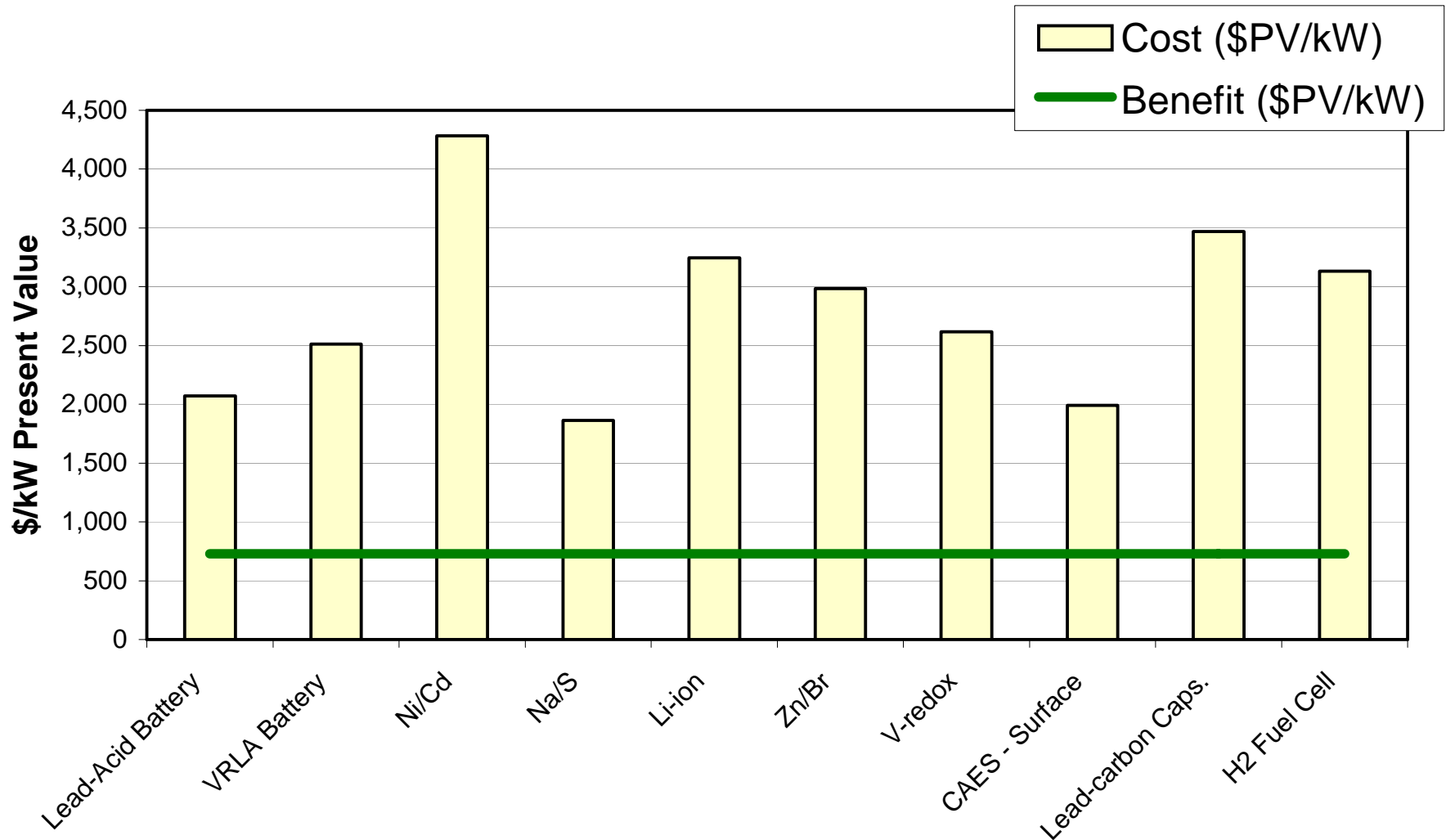


\$100/kW-year
Annual Benefits



Benefit & Cost, Value Proposition 3

Critical Peak Pricing + Peak Reduction



Conclusions

- ☞ California-centric results will be different for different regions & utilities.
- Benefit aggregation is an important way to improve storage value propositions!
- Transportable ESS for Deferral + PQ yields B/C approaching 1 for lead-acid
 - Transportable ESSs offer more opportunities to aggregate benefits.
- Deferral + Arbitrage may be attractive if generation *capacity* benefit is included.

Next Steps

- Consider additional financially attractive and realistic near and mid-term value propositions for ESSs that include
 - Additional use scenarios for transportable ESSs
 - Distributed PV capacity firming.
 - Peak Capacity and Energy for Small and Packaged Air Conditioning.
 - “Critical System Stability” during system/regional grid emergencies.
 - T&D equipment “life extension.”